

PRELIMINARY DATA SUMMARY

February 1989

U.S. Army Engineer Waterways Experiment Station  
Coastal Engineering Research Center  
Field Research Facility  
Duck, North Carolina

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CERC Field Research Facility  
Duck, North Carolina

This report provides a summary of basic oceanographic, meteorological and bottom profile data for the month. The data were obtained as part of the Measurements and Analysis work units at the U.S. Army Engineer Waterways Experiment Station, Coastal Engineering Research Center's Field Research Facility (FRF) in Duck, North Carolina. The FRF staff collected and analyzed these data. These summaries are intended to make the data readily available to all FRF users, and comments on their content and usefulness are invited.

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## PART I: INTRODUCTION

The U.S. Army Engineer Waterways Experiment Station, Coastal Engineering Research Center's (CERC's) Field Research Facility (FRF) is located on the Outer Banks of North Carolina, near the village of Duck (Figure 1).

The FRF research program provides a means for obtaining high-quality field data, particularly during storms, in support of the U.S. Army Corps of Engineers' coastal engineering research missions. The research pier is a reinforced concrete structure supported on 0.9-m-diam steel piles spaced 12.2 m apart along the pier's length and 4.6 m apart across the width. The pier deck is 6.1 m wide and extends from behind the duneline to about the 6-m water depth contour at a height of 7.6 m above the National Geodetic Vertical Datum (NGVD). In addition, a main building contains offices, an instrument repair shop, and a data acquisition room.

One of the responsibilities of the FRF research program is the collection, analysis and dissemination of data on local oceanographic and meteorological conditions. Bottom profiles along both sides of the pier and periodic bathymetric surveys are also performed.

This summary is intended to provide basic data as soon as possible after they are obtained. Questions and/or comments concerning the data may be directed to Mr. Michael W. Leffler at (919) 261-3511.

Part II presents the meteorological data; Parts III through VI present oceanographic data; Part VII presents nearshore profiles and bathymetry; and Part VIII, if included, documents special events that occurred at the FRF during the month.

Table 1 is a list of instruments used, their operational status during the month, and the data collection status. Figure 2 identifies the location of the instruments. The water depths at the wave gages and current meters vary and may be determined from information contained in Figure 7. Other installation information is contained in Table 1.

Times given in the report, unless otherwise specified, are referenced to eastern standard time (EST).

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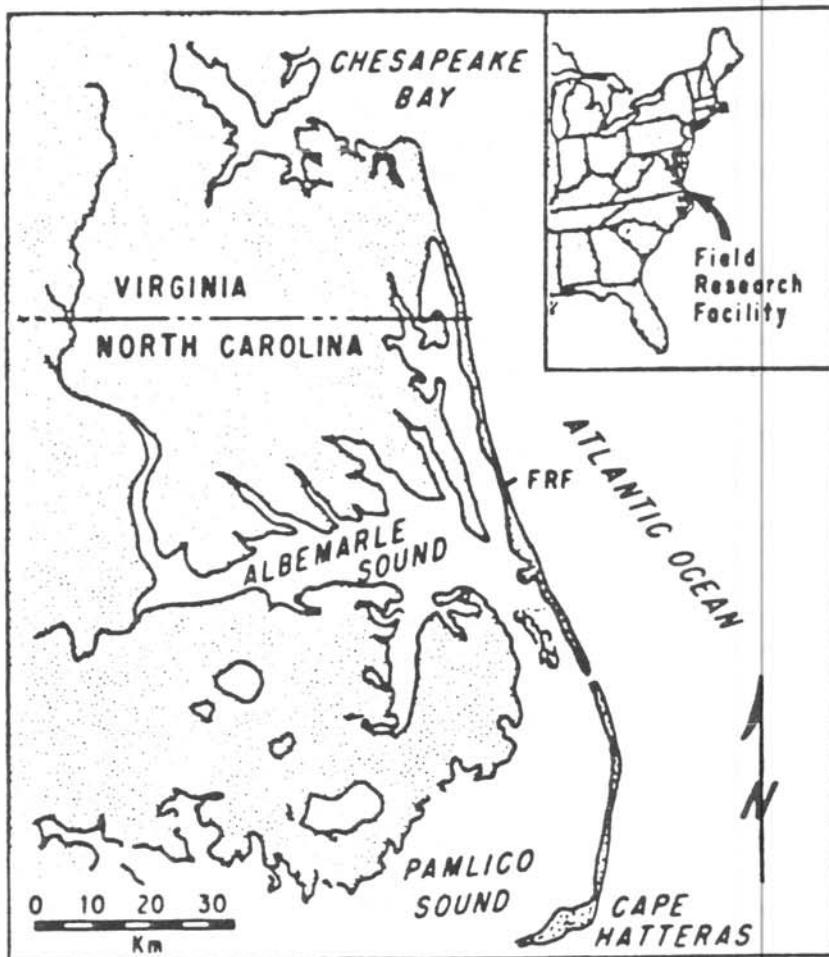


Figure 1. FRF location map

Table 1: Instrument Status/Data Availability

FEB 1989

Gage ID	Description/Remarks	Depth at Sensor	Day of the month																													
			1	2	3	4	5	6	7	8	9	0	1	2	3	4	5	6	7	8	9	0	1	2	3	4	5	6	7	8		
616	Barometric Pressure		Gage Status	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	
			Data Collected	/	*	*	*	*	*	*	*	*	*	*	*	*	/	*	*	*	*	/	*	/	*	*	*	*	*	*		
			Analog Record	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*		
604	Precipitation		Gage Status	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	
			Data Collected	/	*	*	*	*	*	*	*	*	*	*	*	*	/	*	*	*	*	/	*	/	*	*	*	*	*	*		
624	Air Temperature		Gage Status	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	
			Data Collected	/	*	*	*	*	*	*	*	*	*	*	*	*	/	*	*	*	*	/	*	/	*	*	*	*	*	*		
632	Anemometer on Laboratory Building Elevation 19 m (NGVD)		Gage Status	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	
			Data Collected	/	*	*	*	*	*	*	*	*	*	*	*	*	/	*	*	*	*	/	*	/	*	*	*	*	*	*	*	
			Analog Record	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	
645	Baylor staff at station 7+80 on FRF pier	see Figure 7	Gage Status	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	
			Data Collected	-	/	*	*	/	*	*	*	*	/	*	*	*	*	/	*	*	*	/	*	/	*	*	*	*	*	*		
625	Baylor staff at station 18+60 on FRF pier	see Figure 7	Gage Status	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	
			Data Collected	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-			
111	Pressure gage 309 m north of FRF pier (0.9 km offshore)	Approx. 7.8 m NGVD	Gage Status	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
			Data Collected	/	*	*	*	*	*	*	*	*	*	*	*	*	/	*	*	*	*	/	*	/	*	*	*	*	*	*	*	*
630	Waverider buoy 6.0 km offshore	Approx. 23 m NGVD	Gage Status	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
			Data Collected	/	*	*	*	*	*	*	*	*	*	*	*	*	/	*	*	*	*	/	*	/	*	*	*	*	*	*	*	*
679	Current meter 500 m south of FRF pier (0.6 km offshore)	see Figure 7	Gage Status	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	/	-
			Data Collected	/	*	*	*	*	*	*	*	*	*	*	*	*	/	*	*	*	*	/	*	/	*	*	/	-	-	-	-	
865-1370	NOAA tide station at seaward end of FRF pier		Gage Status	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
			Data Collected	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
	Supplemental Observations (daily oceanographic and meteorological observations)		Daily observation	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	/	*	*

Gage Status	Daily Observation	Analog Record	Data Collected
Operational = *	Complete = *	Complete = *	All = *
Partial = /	Partial = /	Partial = /	Partial = /
Non-Operational = -	None = -	None = -	None = -

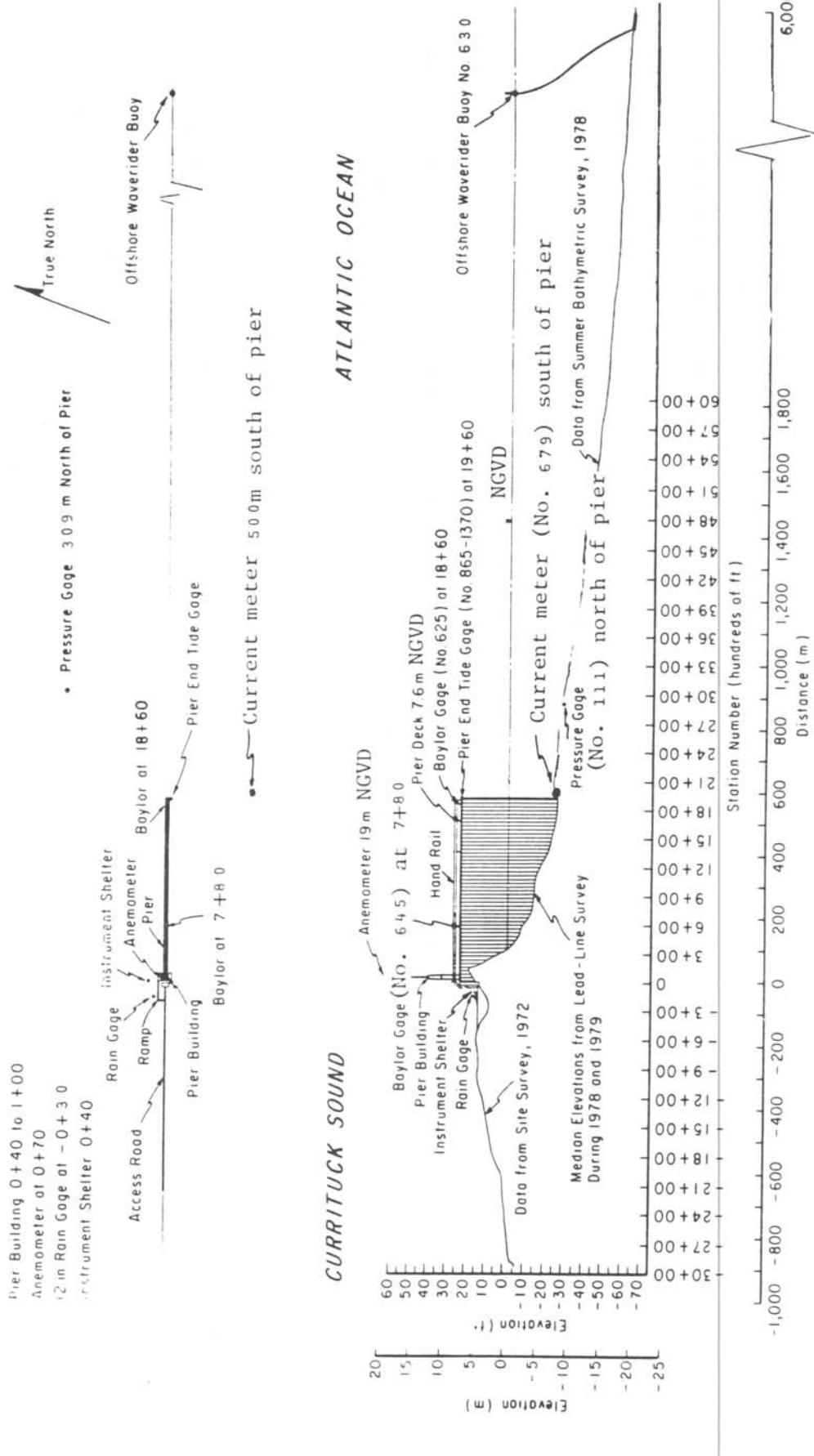


Figure 2. Instrument locations at FRF

## PART II: METEOROLOGICAL DATA

A variety of instruments have been installed at the FRF (Figure 2) to monitor the meteorological conditions. The data presented in Table 2 are collected and stored on magnetic tape using a Digital Equipment Corporation VAX 11/750. For each instrument identified in Table 1 as having analog outputs, chart records are obtained, a log is maintained and the records are stored for future reference.

Winds were measured on top of the laboratory building at an elevation of 19 m (Figure 2) using a Weather Measure Skyvane anemometer.

Monthly resultant wind speeds and directions are determined by vector averaging the data. Temperature and atmospheric pressure means are the average of the values presented for the month. Total precipitation is the sum for the month.

The following may be useful for converting the data in Table 2 to other frequently used units of measurement:

1. Millimeters (mm) to inches (in.) -  
 $mm \times .03937 = in.$
2. Millibars (mb) to inches of mercury (in. Hg) -  
 $mb \times 0.02953 = in. Hg$
3. Degrees Celsius (C) to degrees Fahrenheit (F) -  
 $(C \times 9/5) + 32 = F$
4. Meters per second (m/s) to knots (kn) -  
 $m/s \times 1.943 = kn$

Table 2: Meteorological Data

Feb 1989						
Day	Hour	Wind Speed m/sec	Wind Direction deg TN	Temperature deg C	Atm Pressure mb	Precipitation mm
1	100					0
	700					0
	1300			Hardware Error		0
	1900	7	195	14.6	1012.8	0
2	100	6	212	13.2	1013.8	0
	700	5	202	13.2	1015.2	0
	1300	6	240	19.1	1015.2	0
	1900	5	201	17.9	1016.2	0
3	100	5	203	16.7	1016.2	0
	700	5	193	14.9	1015.5	0
	1300	8	231	22.1	1012.8	0
	1900	9	279	15.8	1013.5	0
4	100	14	9	7.6	1020.9	0
	700	12	13	4.5	1024.7	0
	1300	11	6	3.2	1025.7	0
	1900	10	9	3.9	1025.3	0
5	100	7	13	4.7	1023.6	0
	700	7	2	5.3	1023.0	0
	1300	7	13	4.4	1021.6	3
	1900	6	24	5.5	1021.6	2
6	100	1	298	6.0	1020.3	0
	700	4	238	6.4	1019.6	0
	1300	5	257	7.0	1019.6	0
	1900	1	71	7.3	1019.9	0
7	100	2	47	8.0	1018.6	5
	700	1	96	8.3	1016.2	0
	1300	11	1	5.8	1017.2	0
	1900	9	8	4.3	1022.6	3
8	100	9	24	4.8	1023.0	0
	700	8	18	5.2	1023.6	0
	1300	6	351	5.5	1022.3	0
	1900	2	265	3.8	1021.9	0
9	100	7	291	3.1	1023.3	0
	700	7	294	0.2	1026.7	0
	1300	7	326	1.5	1028.7	0
	1900	4	326	-1.1	1029.4	0
10	100	2	266	-3.5	1027.4	0
	700	5	257	-0.5	1025.0	0
	1300	8	276	3.6	1023.0	0
	1900	0		1.5	1025.3	0
11	100	0		1.2	1023.6	0
	700	2	193	2.9	1021.6	0
	1300	3	245	9.5	1016.9	0
	1900	4	208	7.5	1016.2	0
12	100	4	193	4.5	1015.9	0
	700	4	224	4.5	1015.9	0
	1300	2	351	11.7	1017.5	0
	1900	3	23	6.7	1023.6	0
13	100	4	29	6.6	1027.0	0
	700	5	71	6.5	1029.4	0
	1300	2	57	8.8	1029.1	0
	1900					0
14	100		Software Error			0
	700	2	189	15.8	1026.3	0
	1300	8	193	19.1	1024.7	0
	1900	6	190	16.4	1025.7	0
15	100	6	196	16.0	1026.7	0
	700	6	191	16.8	1027.4	0
	1300	7	198	21.3	1024.7	0
	1900	9	201	17.6	1023.6	0
16	100	8	217	16.0	1024.0	0
	700	6	27	9.8	1028.0	0
	1300	12	15	8.1	1031.8	0
	1900	13	15	6.8	1035.5	0

(Continued)

(Sheet 1 of 2)

Table 2: Meteorological Data

Feb 1989

Day	Hour	Wind	Wind	Temperature	Atm	Precipitation
		Speed m/sec	Direction deg TN	deg C	Pressure mb	mm
17	100	12	14	6.5	1036.5	0
	700	13	28	5.5	1037.5	0
	1300	13	27	3.6	1035.8	0
	1900	12	26	2.5	1034.5	2
18	100	15	22	2.6	1031.1	6
	700	15	23	2.9	1029.4	6
	1300	16	30	4.6	1024.0	7
	1900	15	30	4.8	1021.9	9
19	100	15	5	3.9	1019.6	12
	700	11	6	3.9	1020.9	0
	1300	8	348	3.9	1022.3	0
	1900	4	21	3.1	1023.0	0
20	100	5	21	4.0	1022.6	0
	700	3	11	5.8	1022.6	0
	1300	3	51	9.0	1021.6	0
	1900	3	123	7.6	1020.6	0
21	100	7	82	12.2	1015.9	0
	700		Operator Error			0
	1300	9	177	21.0	1008.1	0
	1900	6	149	11.0	1007.0	6
22	100	4	200	13.4	1007.7	0
	700	5	225	13.1	1007.7	4
	1300	5	246	13.6	1006.4	0
	1900	9	351	7.1	1009.4	0
23	100		Operator Error			0
	700	13	12	6.4	1009.1	0
	1300	16	3	5.3	1008.7	0
	1900	17	9	5.3	1009.4	0
24	100	17	1	5.0	1007.4	5
	700	18	345	0.3	1006.7	7
	1300	13	326	0.1	1010.1	0
	1900	10	313	-1.9	1015.9	0
25	100	9	294	-1.6	1018.2	0
	700	8	298	-4.7	1019.9	0
	1300	6	300	0.5	1018.9	0
	1900	5	263	1.1	1017.9	0
26	100	5	214	0.8	1015.9	0
	700	6	217	2.8	1012.5	0
	1300	9	203	8.5	1004.7	0
	1900	4	227	7.6	1002.6	0
27	100	3	283	5.9	1007.0	0
	700	2	189	5.6	1009.1	0
	1300	2	23	3.6	1011.1	0
	1900	7	40	4.4	1010.4	7
28	100	6	52	6.2	1010.1	16
	700	5	48	7.6	1008.7	3
	1300	4	336	7.2	1008.1	6
	1900	7	328	4.5	1013.8	0
		Resultant 3	350	Mean 7.2	Mean 1019.5	Total 109

(Sheet 2 of 2)

### PART III: WAVE DATA

Wave data are collected from two Baylor staff gages (Gages 625 and 645), a pressure wave gage (Gage 111) and a Waverider buoy (Gage 630) as shown in Table 1 and Figure 2. The data are collected, analyzed, and stored on magnetic tape using a Digital Equipment Corporation VAX 11/750 programmed to sample the wave gages every 6 hr (more frequently during storms) beginning at 0100, 0700, 1300, and 1900 EST. The sampling rate is two times per second for four contiguous 34-min records.

Wave height  $H_{mo}$  is an energy-based statistic equal to four times the standard deviation of the sea surface elevations. Wave height reported from the pressure gage has been compensated for hydrodynamic attenuation using linear wave theory. Wave period is identified from the computation of a variance (energy) spectrum with 60 deg of freedom calculated from a 34-min record. Peak wave period  $T_p$  is defined as the period associated with the maximum energy in the spectrum. When this analysis is complete, the data are written to magnetic tape.

Table 3 presents the wave heights and periods for each wave record obtained at 6 hr intervals during the month. The monthly means and standard deviations from the means shown in Table 3 are average values computed from this data. Figure 3 is a time history of all  $H_{mo}$  and  $T_p$  values obtained for all gages.

Differences in wave periods between wave gages (Table 3 and Figure 3) may be the result of wave breaking, wave reformation, or the presence of multiple wave trains containing nearly equal energy.

Table 3: Wave Data

Feb 1989

Day	Hour	645		625		111		630	
		Baylor at 7+80	Hmo,m T,sec	Baylor at 18+60	Hmo,m T,sec	Pressure Gage	Hmo,m T,sec	Offshr Wvrdr	Hmo,m T,sec
1	0100								
	0700								
	1300								
	1900	*				0.29	7.31	0.43	6.40
2	0100	*				0.34	7.53	0.40	7.53
	0700	*				0.28	9.48	0.41	6.74
	1300	0.19	7.11			0.28	6.56	0.37	6.40
	1900	0.20	9.14			0.28	9.14	0.37	7.31
3	0100	0.21	6.74			0.31	10.24	0.37	5.95
	0700	0.22	9.48			0.31	9.48	0.39	7.11
	1300	0.44	7.31			0.60	7.31	0.68	7.53
	1900	0.48	7.31			0.66	7.31	0.69	7.53
4	0100	1.14	5.95			1.88	6.24	2.06	6.09
	0700	1.33	6.92			1.94	7.11	1.98	7.11
	1300	0.94	7.11			1.61	7.76	1.79	7.53
	1900	1.02	7.31			1.34	4.83	1.50	8.00
5	0100	0.85	5.45			1.13	7.76	1.29	5.82
	0700	0.74	6.92			0.94	7.76	1.05	7.76
	1300	0.80	4.74			1.11	8.53	1.27	8.26
	1900	0.72	4.83			0.93	8.26	1.11	8.53
6	0100	0.65	5.22			0.81	9.14	0.92	8.53
	0700	0.55	5.82			0.76	6.24	0.87	6.40
	1300	*				0.56	6.92	0.64	7.11
	1900	0.31	7.31			0.52	7.31	0.57	6.40
7	0100	*				0.44	8.83	0.46	6.92
	0700	0.26	8.00			0.44	8.26	0.46	8.00
	1300	0.78	3.61			0.80	3.46	0.94	3.77
	1900	1.03	5.69			1.20	5.69	1.36	5.82
8	0100	0.87	5.95			1.06	5.95	1.31	6.24
	0700	0.79	5.69			0.95	5.69	1.00	5.57
	1300	0.69	4.92			0.84	5.12	0.95	5.57
	1900	0.47	5.12			0.65	4.92	0.71	4.92
9	0100	0.37	2.98			0.37	3.33	0.62	3.33
	0700	0.50	5.33			0.51	3.46	0.90	5.22
	1300	1.00	7.11			1.14	7.31	1.40	7.11
	1900	0.85	6.09			0.82	7.31	1.16	5.95
10	0100	0.58	5.33			0.57	5.82	0.76	5.82
	0700	0.29	5.12			0.42	7.31	0.49	5.12
	1300	0.15	9.14			0.26	6.92	0.49	2.56
	1900	0.40	4.20			0.42	4.13	0.43	4.20
11	0100	0.20	5.02			0.28	9.14	0.32	9.48
	0700	0.19	9.48			0.27	9.14	0.40	9.48
	1300	0.15	9.48			0.23	10.67	0.43	9.85
	1900	0.16	9.48			0.25	3.24	0.34	9.48
12	0100	0.13	9.48			0.25	9.48	0.30	8.83
	0700	0.12	9.85			0.23	9.48	0.26	5.82
	1300	0.15	5.12			0.23	9.48	0.34	9.14
	1900	0.78	4.41			0.64	3.88	0.74	4.00
13	0100	0.86	4.92			0.93	5.22	1.05	5.33
	0700	0.90	5.82			1.00	6.09	1.18	5.82
	1300	0.55	4.66			0.71	5.33	0.85	4.92
	1900								
14	0100								
	0700	0.58	6.56			0.83	6.40	1.11	6.56
	1300	0.44	6.40			0.61	6.92	1.02	6.40
	1900	0.47	6.92			0.59	6.74	0.96	6.09
15	0100	0.38	6.74			0.60	6.09	0.82	6.74
	0700	0.34	6.56			0.54	6.56	0.73	6.74
	1300	0.33	6.40			0.45	9.48	0.63	6.40
	1900	0.38	9.85			0.49	10.24	0.71	5.82
16	0100	0.30	5.82			0.51	6.09	0.70	5.69
	0700	0.44	2.94			0.48	10.24	0.70	5.82
	1300	0.90	5.12	1.02	5.12	1.25	4.92	1.29	4.83
	1900	1.09	5.95	1.59	6.09	1.61	5.95	1.75	5.95

\* Electronic problems

(Continued)

Table 3: Wave Data

Feb 1989

Day	Hour	645		625		111		630	
		Baylor at 7+80	Hmo,m T,sec	Baylor at 18+60	Hmo,m T,sec	Pressure Gage	Hmo,m T,sec	Offsho Wvrdr	Hmo,m T,sec
17	0100	1.03	5.82	1.42	5.33	1.48	5.57	1.54	5.12
	0700	1.16	6.92	1.73	6.56	1.88	6.74	2.05	6.56
	1300	1.05	7.31	1.94	7.31	2.17	7.31	2.07	6.92
	1900	1.15	7.11	1.65	5.45	1.79	6.40	1.80	6.56
18	0100	1.09	5.69	1.75	5.57	1.95	5.33	1.99	5.95
	0700	1.27	6.74	2.36	7.31	2.51	6.56	2.47	7.11
	1300	1.17	9.85	2.49	7.76	2.68	7.76	2.79	7.11
	1900	1.32	7.76	2.69	7.53	3.01	8.26	2.99	7.53
19	0100	1.24	9.85	2.61	9.85	2.93	9.85	3.04	9.14
	0700	1.42	8.53	2.40	8.53	2.61	9.85	2.53	8.26
	1300	1.16	10.24	1.86	9.85	1.97	9.48	1.81	9.85
	1900	1.32	11.13	1.63	11.13	1.66	11.13	1.62	10.67
20	0100	1.29	10.24	1.45	10.24	1.55	9.85	1.37	10.24
	0700	0.90	10.24	1.15	10.24	1.22	9.85	1.33	9.85
	1300	0.92	10.24	1.00	10.24	1.10	10.24	1.18	9.85
	1900	0.61	10.24	0.88	9.48	0.91	10.24	0.97	9.85
21	0100	0.64	9.48	0.69	9.48	0.76	10.24	0.86	9.85
	0700					Operator Error			
	1300	1.03	8.53	0.94	8.83	1.09	9.14	1.42	7.76
	1900	0.69	8.26	0.81	9.14	0.93	9.14	1.07	9.14
22	0100	0.79	9.14	0.75	7.76	0.82	8.26	1.01	8.26
	0700	0.69	8.53	0.81	8.53	0.92	8.26	1.06	8.83
	1300	0.63	8.83	0.64	9.85	0.72	9.48	0.89	9.48
	1900	0.91	4.57	1.11	4.66	1.10	9.48	1.36	4.57
23	0100					Operator Error			
	0700	1.25	6.24	1.70	5.95	1.85	5.95	1.99	6.09
	1300	1.02	7.11	2.04	6.92	2.25	6.92	2.33	6.40
	1900	1.21	7.76	3.05	8.00	3.09	8.00	3.30	7.76
24	0100	1.13	9.48	3.08	8.53	3.42	9.48	3.44	8.83
	0700	1.43	10.24	3.77	10.24	3.97	10.24	4.26	10.67
	1300	1.35	12.80	3.55	12.19	3.91	11.64	4.17	12.19
	1900	1.46	12.19	3.61	13.47	3.69	13.47	3.97	12.80
25	0100	1.40	13.47	3.34	13.47	3.30	13.47	3.32	13.47
	0700	1.41	12.80	2.88	12.80	2.42	12.80	2.67	12.80
	1300	1.35	12.80	2.40	12.80	2.06	12.19	2.01	12.19
	1900	1.14	11.64	1.99	11.64	1.55	11.64	1.47	11.64
26	0100	0.66	12.19	1.53	11.64	1.19	11.13	1.08	11.13
	0700	0.43	11.64	1.32	11.13	0.96	11.13	0.92	10.67
	1300	0.35	11.13	1.00	11.13	0.81	10.67	0.88	11.13
	1900	0.23	11.13	0.78	10.24	0.52	10.67	0.58	10.67
27	0100	0.26	10.24	0.78	10.24	0.49	11.13	0.62	11.13
	0700	0.28	11.64	0.74	10.67	0.43	10.67	0.47	10.67
	1300	0.23	11.64	0.79	11.13	0.44	11.64	0.46	10.67
	1900	0.37	2.46	0.89	11.13	0.47	11.13	0.55	10.24
28	0100	0.63	4.41	1.14	4.27	0.80	4.27	0.92	4.57
	0700	0.72	4.74	1.22	5.02	0.92	4.83	1.11	5.12
	1300	0.76	5.57	1.02	5.95	1.11	6.40	1.27	5.95
	1900	1.21	6.40	1.19	6.24	1.27	6.24	1.56	6.40
Mean		0.73	7.61	1.69	8.89	1.14	8.01	1.26	7.59
Std dev		0.39	2.54	0.88	2.49	0.89	2.35	0.88	2.27

\* Electronic problems

(Sheet 2 of 2)

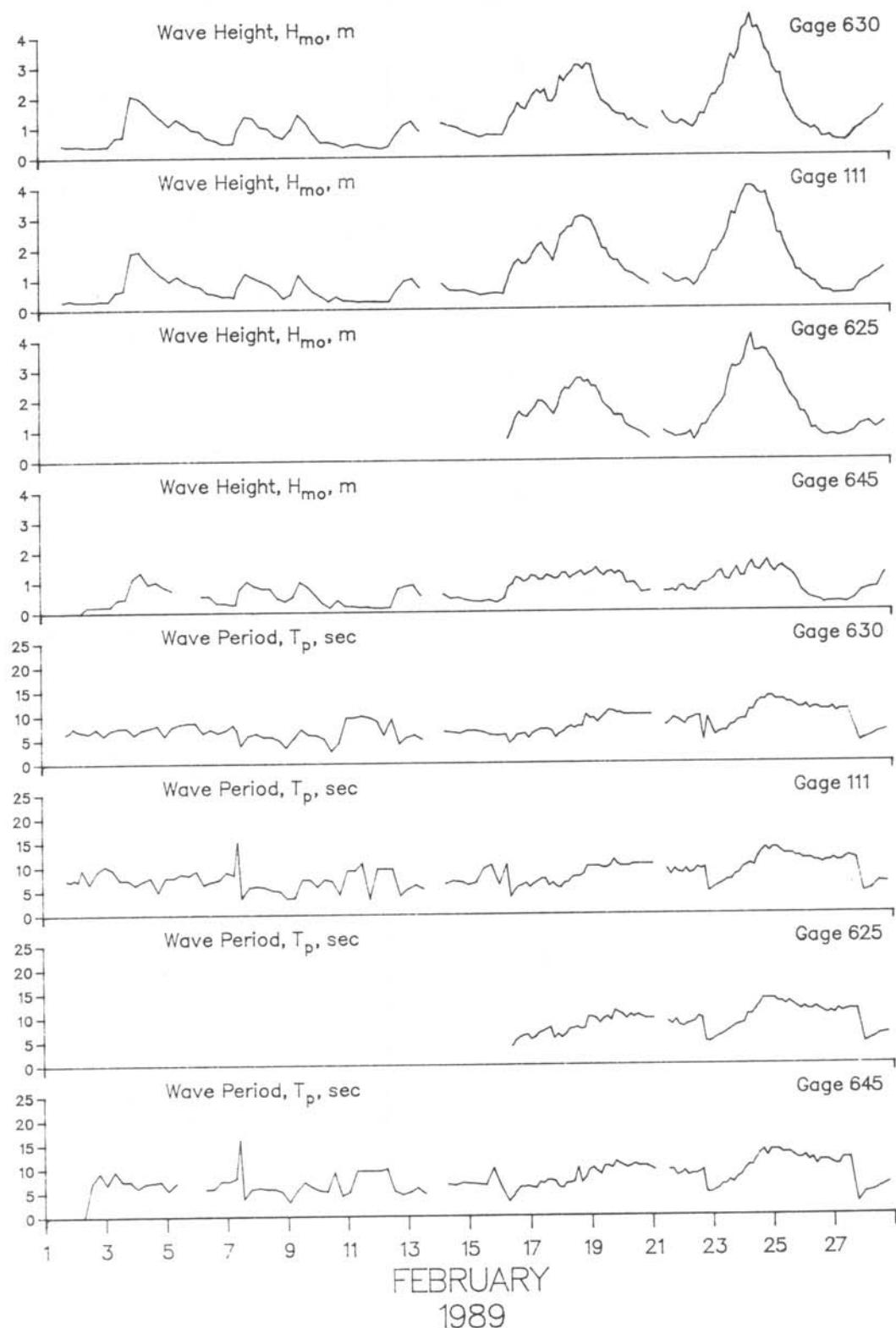


Figure 3. Time history of wave heights and periods

#### PART IV: CURRENT DATA

Current data (Table 4) are collected from a Marsh-McBirney electromagnetic biaxial current meter (Table 1 and Figure 2) and by visually observing the movement of dye on the water surface in the surf and at the seaward end of the pier, as well as 500 m updrift of the pier 12 m offshore.

Since the shoreline orientation is approximately N20W, longshore currents flow either toward 340 deg (i.e. northward) or toward 160 deg (i.e. southward). Similarly, cross-shore currents are either onshore (westward) or offshore (eastward).

All current speeds are given in centimeters per second (cm/sec). Resultant speeds and directions are determined by vector averaging the data.

Table 4: Current Data  
Feb 1989

Day	Time	Pier Measurements				Beach Measurements (500m Updrift)			Current Meter		
		Alongshore Cross-shore Resultant Dye at (579 m) (surface)	Speed	Dir	Dye at Mid-Surf Zone (surface) Distance from Baseline (m)	Speed	Dir	Dye 12m offshore (surface) Location	Speed	Dir	Speed
1	0100-Along Cross Result										
1	0700-Along Cross Result	23	N			19	N		12	N	
		12	off		152	6	off	South			
		26	7			20	357				
1	1300-Along Cross Result										
1	1900-Along Cross Result								4	S	
									3	off	
									5	123	
2	0100-Along Cross Result								4	S	
									3	off	
									5	123	
2	0700-Along Cross Result	5	N			27	N		11	N	
		14	off		152	3	off	South	4	S	
		15	52			27	346		3	off	
2	1300-Along Cross Result								5	N	
									3	on	
									6	309	
2	1900-Along Cross Result								2	S	
									1	on	
									2	187	
3	0100-Along Cross Result								4	S	
									0		
									4	160	
3	0700-Along Cross Result	2	N			11	N		36	S	
		8	off		152	4	off	South	6	S	
		9	56			12	359		0		
3	1300-Along Cross Result								4	S	
									9	off	
									10	94	
3	1900-Along Cross Result								14	S	
									4	off	
									15	144	
4	0100-Along Cross Result								33	S	
									6	off	
									34	150	
4	0700-Along Cross Result	22	S			44	S		33	S	
		0			177	11	on	North	30	S	
		22	160			45	174		5	off	
4	1300-Along Cross Result								30	151	
									26	S	
									4	off	
									26	151	
4	1900-Along Cross Result								24	S	
									2	off	
									24	155	
5	0100-Along Cross Result								14	S	
									1	on	
									14	164	
5	0700-Along Cross Result	61	S			44	S		66	S	
		12	on		165	22	on	North	15	S	
		62	171			49	187		0		
5	1300-Along Cross Result								15	160	
									20	S	
									1	off	
									20	157	
5	1900-Along Cross Result								22	S	
									1	off	
									22	157	

KEY = All speeds in cm/sec  
N = Northward, Shore parallel  
S = Southward, Shore parallel  
on = onshore off = offshore

Table 4: Current Data (Continued)  
Feb 1989

Day	Alongshore Cross-shore Resultant Time	Pier Measurements				Beach Measurements (500m Updrift)				Current Meter		
		Dye at (579 m) (surface)	Speed	Dir	Dye at Mid-Surf Zone (surface)	Distance from Baseline (m)	Speed	Dir	Dye 12m offshore (surface)	Location	Speed	Dir
6 0100	Along Cross Result										11	S
6 0700	Along Cross Result	4 0 4	S off 160		152	0 8 250			34 S	North	1 1 2	N off 7
6 1300	Along Cross Result										2 2 3	S on 205
6 1900	Along Cross Result										0 1 1	off 70
7 0100	Along Cross Result										2 1 2	S off 133
7 0700	Along Cross Result	20 5 21	S on 174		128	7 14 97	S off		29 S	North	3 0 3	N 340
7 1300	Along Cross Result										22 2 22	S off 155
7 1900	Along Cross Result										19 1 19	S off 157
8 0100	Along Cross Result										15 1 15	S off 156
8 0700	Along Cross Result	30 3 31	S on 166		140	55 42 69	S on 197		50 S	North	7 0 7	S 160
8 1300	Along Cross Result										13 2 13	S off 151
8 1900	Along Cross Result										4 1 4	S on 174
9 0100	Along Cross Result										9 0 9	S 160
9 0700	Along Cross Result	38 25 45	S off 127		131	61 30 68	S on 187		79 S	North	4 1 4	S on 174
9 1300	Along Cross Result										16 2 16	S off 153
9 1900	Along Cross Result										2 1 2	S on 187
10 0100	Along Cross Result										4 0 4	N
10 0700	Along Cross Result	14 26 30	N off 42		130	47 9 48	S off 149		2 N	North	9 5 10	340 on 311
10 1300	Along Cross Result										3 5 6	N on 281
10 1900	Along Cross Result										2 1 2	N on 313

KEY = All speeds in cm/sec  
 N = Northward, Shore parallel  
 S = Southward, Shore parallel  
 on = onshore off = offshore

Table 4: Current Data (Continued)  
Feb 1989

Alongshore Cross-shore Resultant Time Day	Pier Measurements				Beach Measurements (500m Updrift)				Current Meter	
	Dye at (579 m) (surface)	Dye at Mid-Surf Zone (surface)	Distance from Baseline (m)	Speed	Dir	Dye 12m offshore (surface)	Location	Speed	Dir	619m Offshore Depth -4.8m (NGVD) ID #679
11 0100-Along Cross Result										3 3 4 25
11 0700-Along Cross Result	55 11 57	N off 351	152	12 6 13	N off 7	9 S	South	8 4 9	N on 313	
11 1300-Along Cross Result										6 3 7 313
11 1900-Along Cross Result										8 2 8 326
12 0100-Along Cross Result										1 2 2 277
12 0700-Along Cross Result	8 10 13	S off 108	138	18 17 25	N off 22	15 S	South	4 2 4	N on 313	
12 1300-Along Cross Result										2 0 2 340
12 1900-Along Cross Result										9 1 9 154
13 0100-Along Cross Result										7 4 8 130
13 0700-Along Cross Result	5 7 8	N on 284	195	17 17 24	S on 205	57 S	North	5 3 6	S off 129	
13 1300-Along Cross Result										2 3 4 36
13 1900-Along Cross Result										
14 0100-Along Cross Result										
14 0700-Along Cross Result	29 10 31	N off 359	189	36 11 37	N off 357	12 S	South	7 4 8	N on 310	
14 1300-Along Cross Result										5 4 6 301
14 1900-Along Cross Result										5 2 5 318
15 0100-Along Cross Result										5 4 6 301
15 0700-Along Cross Result	25 14 29	N off 9	177	41 6 41	N off 349	13 N	South	4 3 5	N on 303	
15 1300-Along Cross Result										4 3 5 303
15 1900-Along Cross Result										9 2 9 327

KEY = All speeds in cm/sec  
 N = Northward, Shore parallel  
 S = Southward, Shore parallel  
 on = onshore off = offshore

Table 4: Current Data (Continued)  
Feb 1989

Alongshore Cross-shore Resultant Time	Pier Measurements				Beach Measurements (500m Updrift)				Current Meter		
	Dye at (579 m) (surface)	Speed	Dir	Dye at Mid-Surf Zone (surface)	Distance from Baseline (m)	Speed	Dir	Dye 12m offshore (surface)	Location	Speed	Dir
Day											
16 0100-Along Cross Result										7	N
16 0700-Along Cross Result	15 3 16	S on 171		177	25 25 36	S on 205		57 S	North	4 1 8	on off 310
16 1300-Along Cross Result										16 1 16	S off 156
16 1900-Along Cross Result										27 3 27	S off 154
17 0100-Along Cross Result										19 2 19	S off 154
17 0700-Along Cross Result	51 76 92	S on 216		235	61 24 66	S on 182		34 S	North	26 3 26	S off 153
17 1300-Along Cross Result										30 5 30	S off 151
17 1900-Along Cross Result										28 3 28	S off 154
18 0100-Along Cross Result										28 2 28	S off 156
18 0700-Along Cross Result	152 152 216	S on 205		308	122 183 220	S on 216		25 N	North	35 4 35	S off 153
18 1300-Along Cross Result										33 9 34	S off 145
18 1900-Along Cross Result										34 9 35	S off 145
19 0100-Along Cross Result										36 14 39	S off 139
19 0700-Along Cross Result	203 20 204	S on 166		201	102 25 105	S on 174		22 S	North	29 2 29	S off 156
19 1300-Along Cross Result										17 0 17	S off 160
19 1900-Along Cross Result										7 5 9	S off 124
20 0100-Along Cross Result										3 5 6	S off 101
20 0700-Along Cross Result	0 3 3			189	22 2 22	N off 346		26 N	South	2 2 3	N on 295
20 1300-Along Cross Result										12 10 16	N off 20
20 1900-Along Cross Result										4 2 4	N off 7

KEY = All speeds in cm/sec  
 N = Northward, Shore parallel  
 S = Southward, Shore parallel  
 on = onshore off = offshore

Table 4: Current Data (Continued)  
Feb 1989

Day	Alongshore Cross-shore Resultant Time	Pier Measurements				Beach Measurements (500m Updrift)			Current Meter	
		Dye at (579 m) (surface)	Speed	Dir	Distance from Baseline (m)	Speed	Dir	Dye 12m offshore (surface)	Location	Speed
21	0100-Along Cross Result									619m Offshore
										Depth -4.8m
										(NGVD)
										ID #679
21	0700-Along Cross Result	61	N			122	N	51	N	7
		30	off		140	0		South		1
		68	7			122	340			7
21	1300-Along Cross Result									152
21	1900-Along Cross Result									37
										5
										on
										37
										332
21	1900-Along Cross Result									17
										N
										4
										on
										17
										327
22	0100-Along Cross Result									8
										N
										2
										on
										8
										326
22	0700-Along Cross Result	22	N			61	N	48	N	15
		8	off		143	30	on	South		4
		23	359			68	313			16
22	1300-Along Cross Result									325
										7
										N
										2
										7
										324
22	1900-Along Cross Result									11
										S
										1
										off
										11
										155
23	0100-Along Cross Result									
23	0700-Along Cross Result	102	S			305	S	72	S	30
		30	on		189	305	on	North		5
		106	177			431	205			30
23	1300-Along Cross Result									42
										8
										43
										149
23	1900-Along Cross Result									72
										S
										10
										off
										73
										152
24	0100-Along Cross Result									76
										S
										17
										off
										78
										147
24	0700-Along Cross Result									118
										S
										27
										off
										121
24	1300-Along Cross Result									116
										1
										on
										116
24	1900-Along Cross Result									32
										off
										44
										117
25	0100-Along Cross Result									32
										S
										31
										off
										45
										116
25	0700-Along Cross Result	41	S			76	S	25	N	32
		41	off		238	19	off	North		32
		57	115			79	146			45
25	1300-Along Cross Result									115
										31
										S
										34
										off
										46
										112
25	1900-Along Cross Result									31
										S
										34
										off
										46
										112

KEY = All speeds in cm/sec

N = Northward, Shore parallel

S = Southward, Shore parallel

on = onshore off = offshore

Table 4: Current Data (Concluded)  
Feb 1989

Day	Alongshore Cross-shore Resultant ---- Time	Pier Measurements						Beach Measurements (500m Updrift)			Current Meter	
		Dye at (579 m) (surface)		Dye at Mid-Surf Zone (surface) Distance from Baseline (m)		Dye 12m offshore (surface)		Location	Speed	Dir	Speed	Dir
26	0100-Along Cross Result	Speed	Dir								31	S
											34	off
											46	112
26	0700-Along Cross Result	32	N			14	N		28	N	31	S
		19	off	152		21	off	South			35	off
		37	11			25	36				47	112
26	1300-Along Cross Result										31	S
											35	off
											47	112
26	1900-Along Cross Result										31	S
											35	off
											47	112
27	0100-Along Cross Result										31	S
											35	off
											47	112
27	0700-Along Cross Result	41	N			14	N		6	S		
		2	on	140		2	off	South				
		41	337			14	349					
27	1300-Along Cross Result											
27	1900-Along Cross Result											
28	0100-Along Cross Result											
28	0700-Along Cross Result	12	S			17	S		28	N		
		1	on	201		3	off	North				
		12	163			18	149					
28	1300-Along Cross Result											
28	1900-Along Cross Result											

KEY = All speeds in cm/sec  
 N = Northward, Shore parallel  
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#### PART V: SUPPLEMENTAL OBSERVATIONS

Visual wave direction measurements (Table 5) of both the primary wave train (i.e. that having the larger wave heights) and the secondary wave train (which must be clearly distinguishable as a wave train separate from the primary waves but not surface chop or capillary waves) are taken daily at the seaward end of the pier. The direction of the primary wave train just north of the seaward end of the pier is also determined using a Raytheon Marine Pathfinder radar and measuring the alignment of the wave crests at approximately the same location as the visual measurements. The pier axis (considered perpendicular to the beach at the FRF) is orientated 70 deg east of true north; consequently, wave angles greater than 70 deg indicate that the waves were coming from the south side of the pier.

The width of the surf zone (seawardmost breaker position to shoreline) is determined from the pier deck.

Measurements of surface water temperature, density, and visibility are also taken daily at the seaward end of the pier. A jar along with a thermometer is lowered about 0.3 m into the water and allowed to remain for at least one minute. The jar is removed, the temperature read, and a hydrometer is used to determine the density. A Secchi disc is used to determine the surface visibility.

Table 5: Supplemental Observations

Feb 1989

Day	Time	Wave Approach		Radar Wave Angle deg from True N	Width of Surf Zone,m	Water Characteristics at Pier End		
		Primary	Secondary			Temp.,C	Density g/cc	Secchi Vis.,m
1	0716	none visible			12	8.4	1.0258	3.0
2	0818	none visible			3	9.7	1.0265	3.4
3	0845	none visible			21	10.0	1.0264	3.4
4	0945	55		60	171	7.2	1.0248	1.2
5	0903	none visible		40	152	7.5	1.0240	0.6
6	0858	20			16	8.1	1.0246	1.5
7	0930	none visible			30	8.1	1.0244	1.8
8	0750	8		22	58	6.9	1.0244	2.1
9	0841	353		7	34	6.1	1.0244	1.5
10	0833	60			20	6.4	1.0242	1.8
11	0812	none visible			6	7.0	1.0248	3.0
12	1042	none visible			10	8.3	1.0260	5.5
13	0735	34		42	140	7.2	1.0256	4.0
14	0832	86	115	86	101	8.4	1.0256	3.4
15	0746	92	102		26	9.1	1.0262	3.4
16	0737	23		96	77	8.9	1.0264	4.6
17	0758	42		30	224	8.3	1.0262	1.2
18	1022	56	30	61	466	6.4	1.0226	1.2
19	0918	49	57	68	273	5.9	1.0216	0.9
20	0807	77		73	168	6.1	1.0224	0.9
21	0706	90	130	88	27	8.3	1.0240	0.6
22	0808	83	92		34	7.8	1.0256	1.8
23	0756	25	35	43	219	7.0	1.0260	0.6
24	0906	no observation			651			
25	1125	50		55	287	4.4	1.0224	0.9
26	1107	none visible			15	5.6	1.0242	0.9
27	0819	15			16	5.0	1.0246	1.2
28	0745	61	30	66	163	5.3	1.0246	1.2

## PART VI: WATER LEVELS

Since 1978, the National Oceanic and Atmospheric Administration (NOAA)/National Ocean Service (NOS) has operated a primary tide station (No. 865-1370) at the seaward end of the FRF pier. A Leupold-Stevens digital recording float-type tide gage is used to collect instantaneous water level data every 6 minutes throughout the month.

The variation in water level during the month is shown in Figure 4 along with a list of mean and extreme values. This presentation is useful in identifying effects of both meteorological and astronomical forces on the open coast water level.

Table 6 contains the time at the center of each 12.42-hr tidal cycle and the range, high, low, and mean water levels during each tidal cycle.

## FRF Tide Heights

Feb 1989

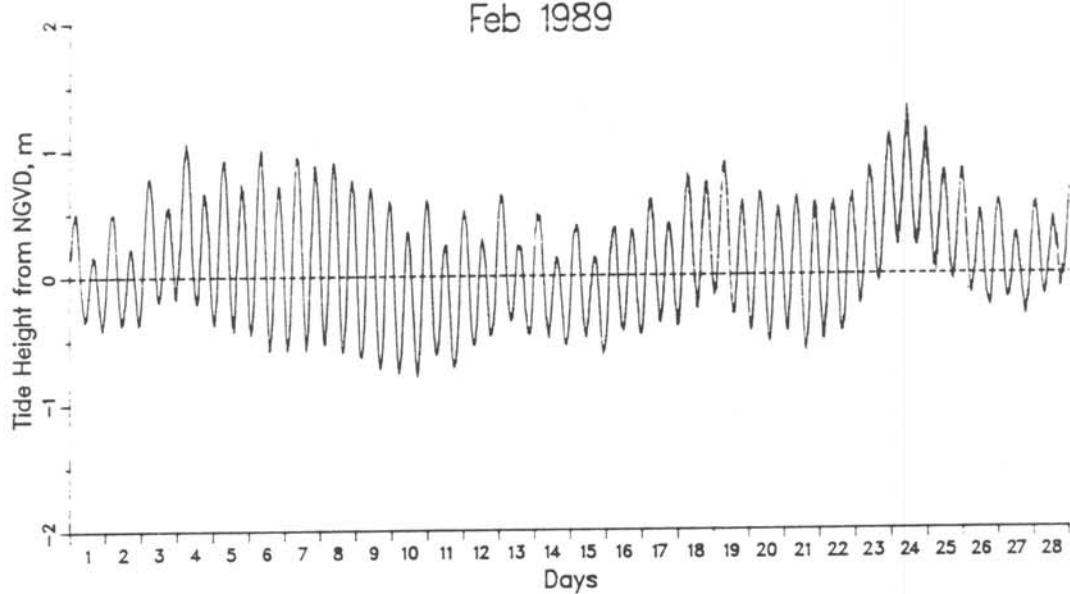


Figure 4. Water level time history

### Monthly Water Levels, m NGVD

Extreme Low = -0.79 on day 10 at 1630 hr  
Extreme High = 1.33 on day 24 at 924 hr  
Monthly Mean = 0.13  
Mean Low = -0.37  
Mean High = 0.63  
Mean Range = 1.00

Table 6: Water Levels, m NGVD

		Feb 1989			
Mid-Cycle Day	Time	Low	High	Mean	Range
1	612	-0.35	0.51	0.07	0.86
1	1837	-0.41	0.17	-0.09	0.58
2	703	-0.37	0.51	0.07	0.88
2	1928	-0.38	0.27	-0.04	0.65
3	753	-0.20	0.78	0.29	0.98
3	2018	-0.17	0.56	0.24	0.73
4	843	-0.21	1.06	0.42	1.27
4	2109	-0.37	0.67	0.15	1.04
5	934	-0.43	0.93	0.29	1.36
5	2159	-0.46	0.74	0.15	1.19
6	1024	-0.59	1.01	0.22	1.59
6	2249	-0.58	0.72	0.10	1.30
7	1115	-0.58	0.95	0.23	1.53
7	2340	-0.53	0.88	0.17	1.41
8	1205	-0.59	0.91	0.15	1.50
9	30	-0.64	0.76	0.05	1.40
9	1255	-0.72	0.70	-0.03	1.42
10	121	-0.77	0.59	-0.09	1.36
10	1346	-0.79	0.35	-0.20	1.14
11	211	-0.62	0.60	-0.03	1.22
11	1436	-0.71	0.24	-0.24	0.95
12	301	-0.54	0.52	-0.02	1.06
12	1527	-0.47	0.30	-0.09	0.77
13	352	-0.35	0.64	0.14	1.00
13	1617	-0.46	0.24	-0.09	0.70
14	442	-0.49	0.49	0.04	0.98
14	1707	-0.55	0.15	-0.19	0.69
15	532	-0.49	0.40	-0.01	0.88
15	1758	-0.62	0.15	-0.21	0.77
16	623	-0.44	0.38	-0.02	0.82
16	1848	-0.46	0.36	-0.05	0.82
17	713	-0.37	0.60	0.13	0.97
17	1938	-0.40	0.41	0.02	0.81
18	804	-0.26	0.80	0.28	1.06
18	2029	-0.17	0.74	0.27	0.91
19	854	-0.30	0.90	0.30	1.20
19	2119	-0.44	0.59	0.08	1.03
20	944	-0.53	0.66	0.09	1.18
20	2210	-0.44	0.54	0.05	0.98
21	1035	-0.60	0.62	0.04	1.22
21	2300	-0.51	0.57	0.02	1.07
22	1125	-0.45	0.59	0.06	1.04
22	2350	-0.23	0.65	0.21	0.88
23	1216	-0.06	0.85	0.39	0.91
24	41	0.23	1.11	0.67	0.88
24	1306	0.22	1.33	0.70	1.11
25	131	0.02	1.15	0.56	1.13
25	1356	-0.05	0.82	0.38	0.87
26	222	-0.16	0.83	0.31	0.99
26	1447	-0.26	0.51	0.11	0.77
27	312	-0.20	0.59	0.18	0.78
27	1537	-0.33	0.32	0.01	0.65
28	402	-0.17	0.57	0.19	0.74
28	1628	-0.11	0.51	0.19	0.62
29	453	0.52	0.67	0.60	0.14

## PART VII: NEARSHORE PROFILES

A. Nearshore Profiles. In order to document profile response away from the pier, surveys of four profile lines extending 900 to 1,000 m from shore and located 489 and 581 m north and 517 and 608 m south of the FRF pier are conducted bi-weekly, after storms, and during more complete bathymetric surveys.

These profiles are obtained using the CRAB-Zeiss surveying system; a Zeiss Elta-2 first-order, self-recording electronic theodolite distance meter in combination with the Coastal Research Amphibious Buggy (CRAB), a 10.7 m high, self-powered, mobile tripod on wheels.

Figure 5 shows the last survey in January 1989 and four surveys in February on profile line 188, located 517 m south of the pier. Minor changes occurred through the 21 February survey; however, the major storm on 23-25 February caused substantial changes. The most dramatic change was the large area of accretion seaward of the storm bar (340 m), a portion of the profile which generally shows little variation. Up to 0.4 m of accretion extends from the crest of the storm bar (340 m) to the profile's seawardmost point, a distance of 440 m. The storm bar crest migrated 60 m offshore with up to 1 m of erosion on the shoreward face (200 to 320 m). Additional erosion is visible on the beach face from the toe of the dune (70 m) to the NGVD intercept (115 m) where a small nearshore bar (120 m) formed.

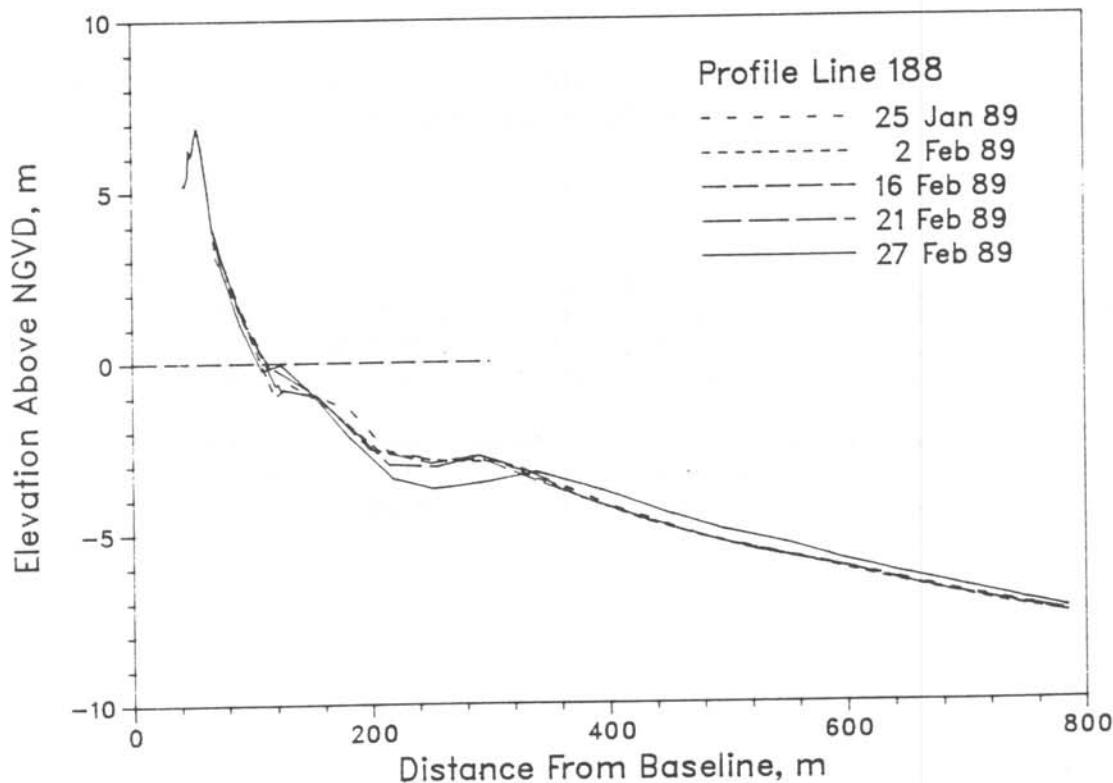


Figure 5. Monthly CRAB profiles on profile 188 - 517 m south of pier.

The profile envelope (Figure 6) reflects the maximum changes that occurred on the profile during 1989. Virtually all the changes to the envelope during February resulted from the 23-25 February storm.

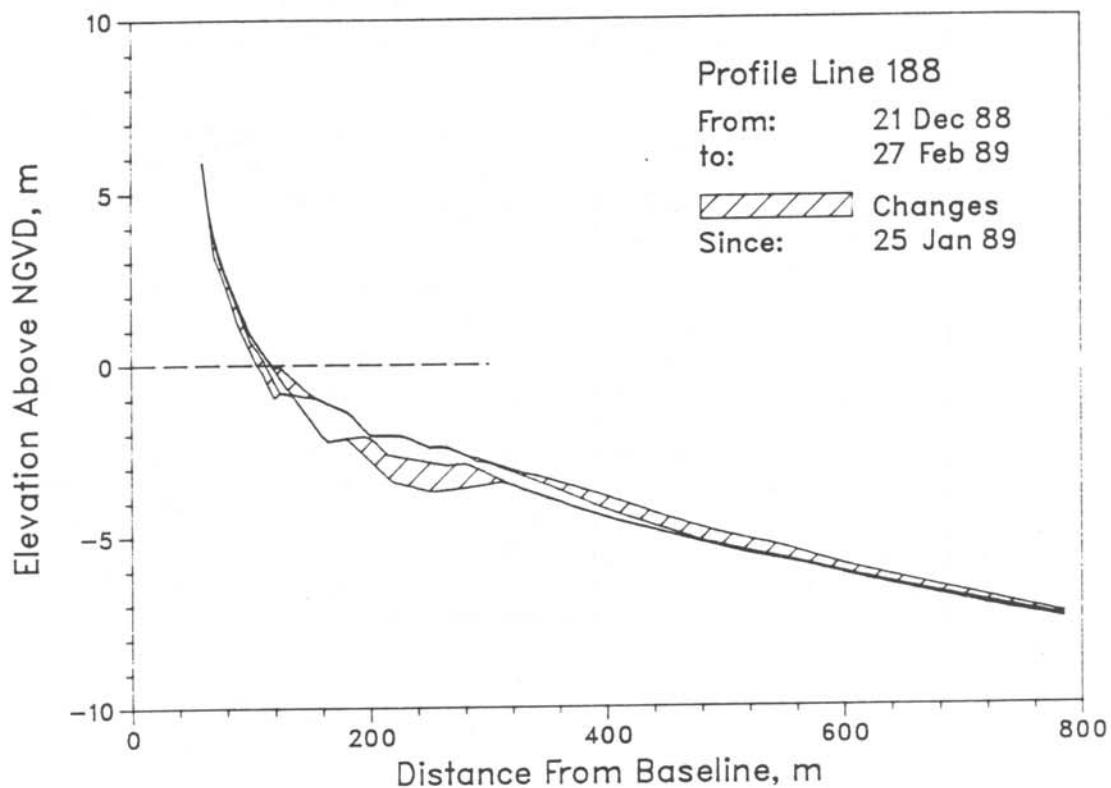


Figure 6. CRAB profile envelope - profile 188.

B. Bathymetry. Figures 7 and 8 include two- and three-dimensional contour maps and change plots derived from the bathymetric surveys conducted on 21 and 27 February 89, respectively. Wide contour lines on the change diagram represent areas that eroded; thin lines indicate accretion.

Figure 8 documents the significant changes caused by the intense 23-25 February storm. Of special interest is the significant cross-shore movement of sediment all along the survey region and the deepening of the scour hole at the seaward end of the pier.

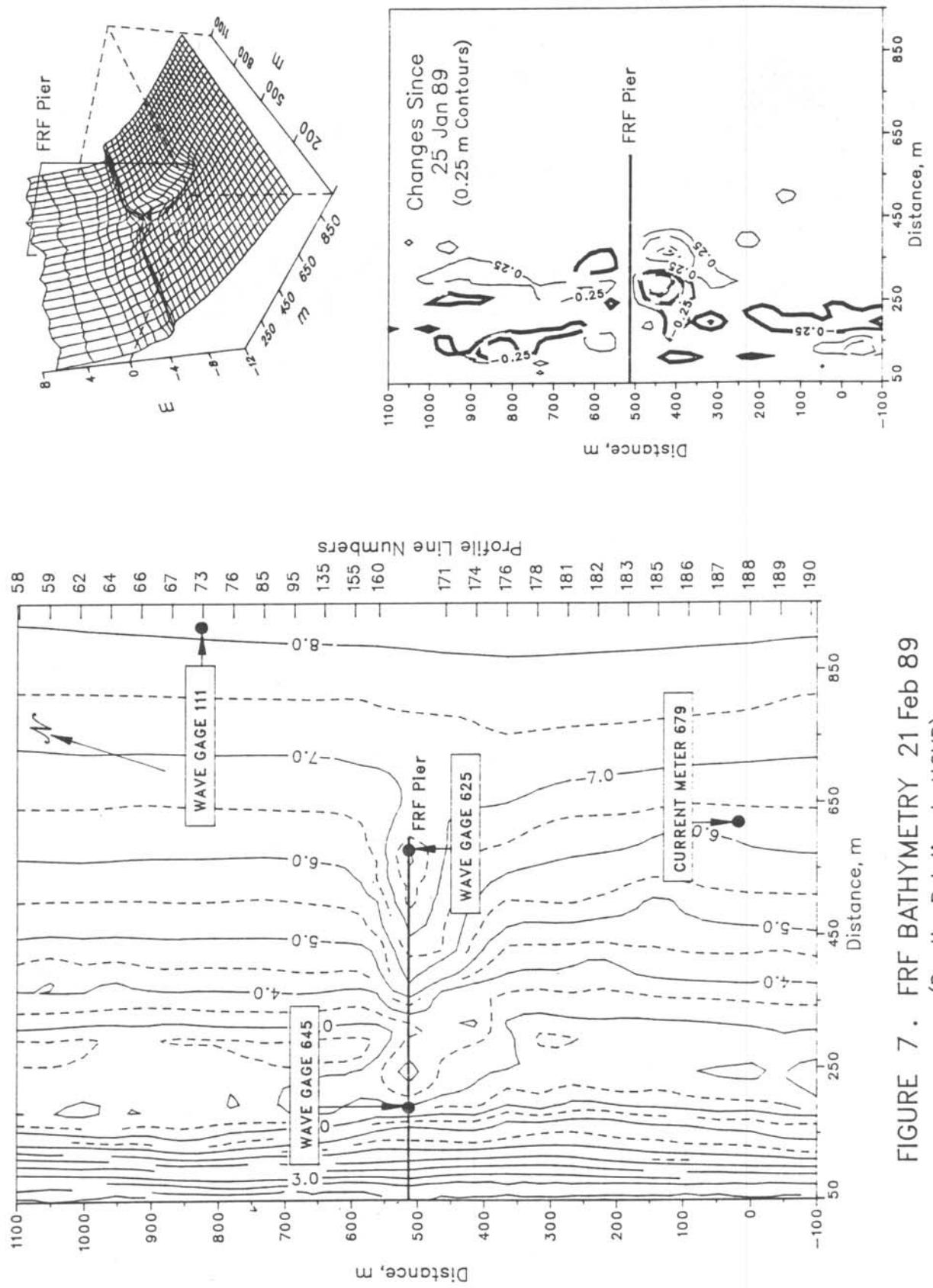


FIGURE 7 . FRF BATHYMETRY 21 Feb 89  
(Depths Relative to NGVD)

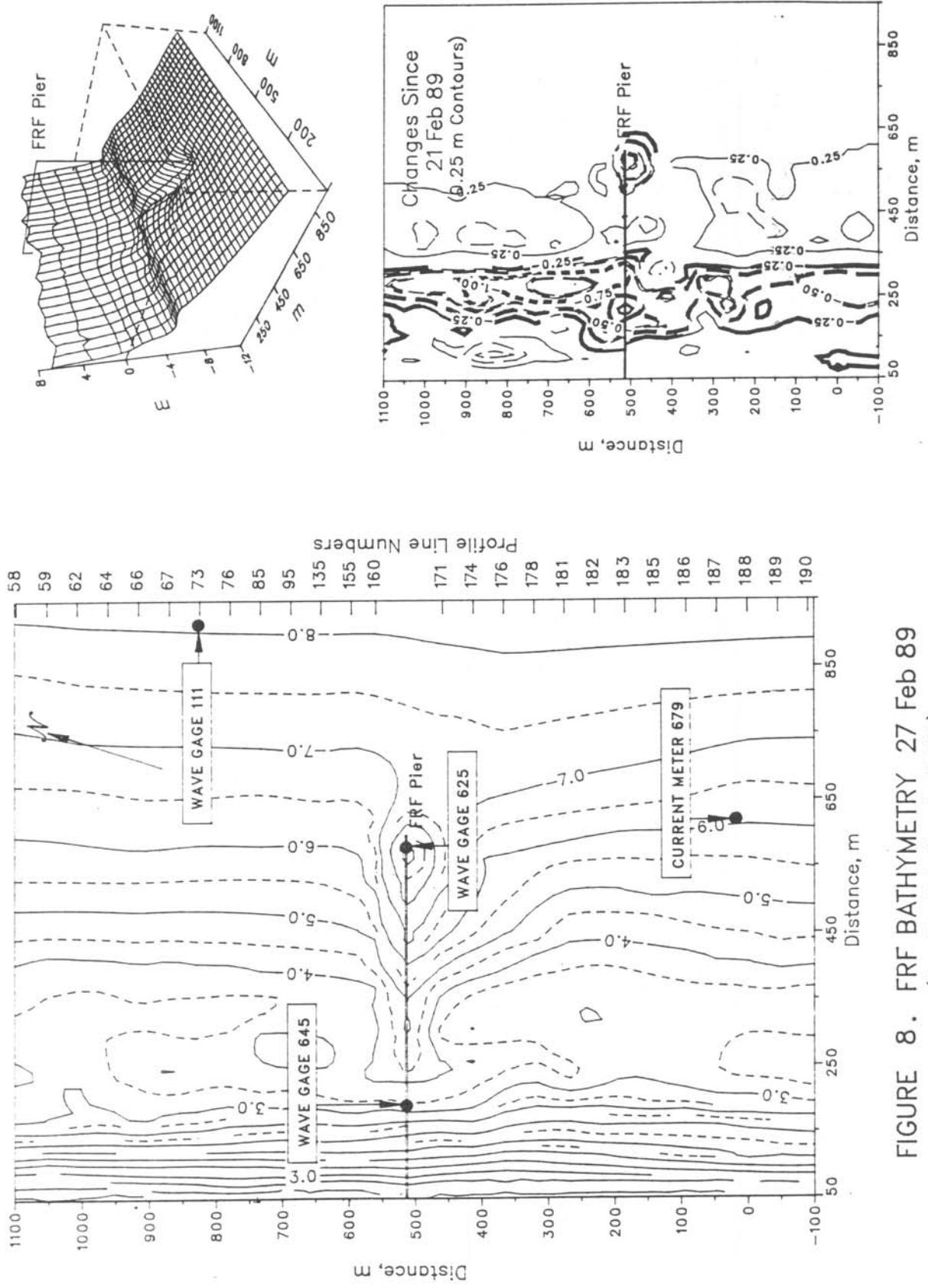


FIGURE 8. FRF BATHYMETRY 27 Feb 89  
(Depths Relative to NGVD)

## PART VIII: SPECIAL EVENTS

A. Storm Data Collection. The following list identifies times when wave heights exceeded 2 m at the seaward end of the pier. When this occurred, four contiguous 34-min wave records were obtained every three hours:

<u>Start</u>	<u>End</u>
17 Feb (1034)	19 Feb (1108)
23 Feb (1300)	25 Feb (1708)

B. Storm Synopsis.

17-19 February - Strong onshore winds (from northeast) generated by a Canadian high pressure system were reinforced by the formation of a storm off the North Carolina coast early on 18 February. Blocked by the high pressure system to the north, the storm quickly moved offshore. Peak winds (from northeast) exceeded 16 m/s, coinciding with the maximum  $H_{mo}$  (Gage 625) of 2.86 m ( $T_p = 7.53$  sec). Both events were recorded on 18 February at 1634 EST. The minimum atmospheric pressure of 1019 mb occurred on 19 February at 0242 EST. Total precipitation was 42 mm.

23-25 February - This powerful Northeaster developed off the North Carolina coast on 23 February and rapidly intensified. On 24 February, the storm picked up speed as it moved up the coast and was located off the New England coast by 25 February. Onshore winds (from north) approached 20 m/s at 0434 EST on 24 February followed by the maximum  $H_{mo}$  (Gage 625) of 4.09 m ( $T_p = 11.13$  sec) at 1000 EST. The minimum atmospheric pressure of 1006.1 mb was recorded the same day at 0242 EST. Total precipitation was 12 mm. A number of cottages and motels along the Outer Banks were damaged by this storm and erosion was severe to much of the oceanfront dune system resulting in scarpes up to 7 m in height.

### Distribution List

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OCE	U.S. Geological Survey
BERH	U.S. National Park Service
NAO	U.S. Naval Academy
NASA/Wallops Flight Center	U.S. Naval Civil Eng. Lab
NOAA (NOS, NWS)	U.S. Naval Fac. Eng. Com.
SAD	U.S. Naval Oceanographic Off.
SAW	U.S. Naval Research Lab

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